US Army Corps of Engineers

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Design Construction Analysis Feedback

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CEMP-CE

Subject: Silica-Fume Concrete

Applicability: Information

1. Most construction materials and systems tend to improve over the years. Those that do not often become obsolete. Usually these individual improvements are relatively small ones. It is rare that technology provides a cardinal change to a major construction material. However, the pozzolan, silica-fume can make significant improvements to many of the important properties of hardened concrete:

a. Permeability of concrete to liquids and vapors is reduced by silica-fume addition. Permeability is related to durability, therefore concrete is made more durable by the addition of silica-fume.

b. Compressive strength increases when silica-fume is added. With the proper design mix, strengths in excess of 20,000 psi are readily obtained.

c. Flexural and splitting tensile strength show increases proportional to the compressive strength.

d. Bond strength shows significant improvement at three types of interfaces: aggregate, reinforcing bars, and old concrete.

e. Surface abrasion and scaling appear less severe for silica-fume concrete. This is related to durability.

f. Resistance to chemical attack by acids, sulfates, and chlorides is improved by the addition of silica-fume. This is related to the lowered permeability.

g. Alkali-aggregate reaction is significantly inhibited by the use of silica-fume.

2. Silica-fume is a by-product in the manufacture of ferrosilicon alloys for the electronics industry. It consists of very fine spherical silicon dioxide particles that condense from the gas produced in the process. In the early 1950s

environmental concerns in the Scandinavian countries placed controls on the release of silica-fume into the atmosphere. This initiated the use of silica-fume as a pozzolan. Since that time, a plethora of investigations has been conducted in many countries defining the use and advantages of silica-fume concrete. More recently, the use of high range water reducing admixtures (HRWRA) has made the use of silica-fume concrete easier.

3. The mechanism by which silica-fume modifies conventional concrete is primarily due to the extremely small size of the individual particles. It has been estimated that for 15% silica-fume concrete, there are two million particles of silica-fume for each particle of cement. Silica-fume improves the strength permeability, durability, etc. of concrete by "packing" the transition zone between the cement paste and the aggregate particles, thus increasing the bond strength between the cement and the aggregate.

4. The guide specifications for concrete (CEGS 03300 & CWGS 03301, Cast-in-Place Structural Concrete) are not completely applicable to silica-fume concrete. The BCOE reviewer should ascertain that the following topics are adequately covered in the specifications:

a. Measuring, batching, & mixing should be very precise regarding the amount of silica-fume being specified. Because of the large volume of silica-fume slurry as compared to the usual admixtures (in some cases a factor of over 100) extra mixing may be required for uniform dispersion. In any event, all dispensing equipment should conform to ACI 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete, and ASTM C 94, Standard Specifications for Ready Mixed Concrete. Also, because of different forms of silica-fume concrete that are available, the specifications should be clear regarding the amount of silica-fume that is required.

b. Placing and consolidation is essentially covered by the guide specification. However, entrapped air can be a problem even at high slumps because of the cohesive nature of silica-fume concrete. Adequate vibration is crucial.

c. There are different techniques for finishing silica-fume concrete. The factors that affect this finishing are the absence of bleed water, the cohesive nature of the concrete, and the tendency to develop plastic shrinkage cracks.

d. Curing procedures must begin immediately after finishing to prevent plastic shrinkage cracks. In fact, the fogging of a slab is done as part of the finishing process.

e. Pre-construction testing should be conducted to assure that the design mix will produce concrete that will meet design requirements. This testing should include sample placements.

5. Finishing silica-fume concrete involves different techniques than conventional concrete, and dire consequences can be expected if the contractor and his finishing crew are not prepared for the difference. In general, it should be noted that placing, finishing and curing must be performed in a continuous operation, with finishing (troweling) kept to a minimum. The absence of bleed water tends to increase the stickiness of the concrete which makes the screeding and troweling more difficult than conventional concrete. As stated above, pre-construction testing should include sample slab placements. These sample placements are essential when crews are inexperienced in working with silica-fume concrete, and they also serve to confirm the use of placing equipment such as vibratory screeds, which are strongly recommended for placement of slabs.

6. There are many Corps projects for which the use of silica-fume concrete is the material of choice. One thing is certain, the use of this material will increase in the near future. We should provide definitive guidance for its use now. The American Concrete Institute will release a "Guide for the Use of Silica-Fume Concrete" in early 1996. It is recommended that each district and field office obtain a copy of this publication to be used as a guide for BCOE reviews.

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